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NBursts: Simultaneous Extraction of Internal Kinematics and Parametrized SFH from Integrated Light Spectra

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Abstract. We present a novel approach for simultaneous extraction of stellar population parameters and internal kinematics from the spectra integrated along a line of sight. We fit a template spectrum into an observed one in a pixel space using a non-linear χ^2 minimization in the multidimensional parameter space, including characteristics of the line-of-sight velocity distribution (LOSVD) and parametrized star formation history (SFH). Our technique has been applied to IFU and multi-object spectroscopy of low-luminosity early type galaxies.

Keywords. techniques: spectroscopic, methods: data analysis, galaxies: abundances

1. Introduction

In a "classical" way, extraction of stellar population parameters and internal kinematics from absorption-line spectra of galaxies, integrated along a line of sight go independently. Internal kinematics is determined by deconvolving the observed spectrum with a single spectrum of a star ("template spectrum"), observed with the same setup (see e.g. Sargent et al. 1977), or with a linear combination of template spectra (optimal template fitting) (van der Marel & Franx, 1993). Stellar population parameters are normally estimated using absorption line strength indices: low-resolution (∼10Å) Lick indices (Worthey et al. 1994), or intermediate-resolution indicators (e.g. Vazdekis & Arimoto, 1999).

Caveats of the classical approaches are: (1) the template mismatch, putting limitations on the precision of kinematics, (2) non-optimal usage of information, contained in the spectrum, when measuring absorption line strength indices. One of the modern approaches, STECKMAP (Ocvirk et al. 2006) performs analysis of the complete spectral energy distribution to extract simultaneously SFH and LOSVD in a non-parametric way.

2. The NBursts method and its applications

We propose a new approach for determination of parametrized LOSVD and SFH. Our method is the generalization of the penalized pixel fitting algorithm (Cappellari & Emsellem, 2004). An optimal template is represented by the linear combination of

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SSP's with free ages and metallicities, determined in the same minimization loop, using interpolation of the pre-computed grid of PEGASE.HR SSP's (Le Borgne et al. 2004).

The χ^2 value (without penalization) is computed as follows:

$$\chi^2 = \sum_{N_\lambda} \frac{(F_i - P_{1p}(T_i(SFH) \otimes \mathcal{L}(v, \sigma, h_3, h_4) + P_{2q}))^2}{\Delta F_i^2},$$

$$\text{where} \quad T_i(SFH) = \sum_{N_{bursts}} k_i T_i(t_n, Z_n) \tag{2.1}$$

where $\mathcal{L}$ is LOSVD; F_i and ΔF_i are observed flux and its uncertainty; $T_i(SFH)$ is the flux from an synthetic spectrum, represented by a linear combination of N_{bursts} SSP's and convolved according to the line-spread function of the spectrograph; P_{1p} and P_{2q} are multiplicative and additive Legendre polynomials of orders p and q for correcting the continuum; t is age, Z is metallicity, v, σ, h_3, and h_4 are radial velocity, velocity dispersion and Gauss-Hermite coefficients respectively (Van der Marel & Franx, 1993). Precision of the parameter estimates with our technique are discussed in details in Koleva et al. 2006.

The simplest case, $N_{burst} = 1$, allows to compare of with the stellar population parameters derived using Lick indices. Due to optimized usage of information contained in the spectra, our technique provides 2 to 5 time better precision compared to Lick indices for the same S/N ratio for a typical spectral range and resolution of modern intermediate-resolution instruments: 4200Å$< \lambda <$5600Å; $R = 1800$.

We used NBursts to analyse data on early type dwarf galaxies: (1) 3D spectroscopy of dE galaxies in the Virgo cluster and nearby groups (MPFS IFU spectrograph at the Russian 6-m telescope), (2) high-resolution multi-object spectroscopy of a sample of early-type galaxies in the Abell 496 cluster (FLAMES-Giraffe at ESO VLT).

Details on the results and interpretation are available in Chilingarian (2006, PhD thesis). Kinematically (Chilingarian et al. 2007) and evolutionary (Chilingarian et al. 2006) decoupled structures are revealed in most of the galaxies from our 3D spectroscopic sample. Disky features and intermediate-age stellar population strengthen the connection between early and late-type dwarf galaxies

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